

**IN THE ABSTRACT:**

Delete the abstract now of record and insert therefor the new abstract submitted herewith of on a separate sheet.

**ADDITIONAL FEES:**

No additional fees are believed required; however, should it be determined that a fee is due, authorization is hereby given to charge any such fee to our Deposit Account No. 01-0268.

**REMARKS**

In the last Office Action, claims 1-7 were rejected under 35 U.S.C. §103(a) as being unpatentable over the international journal publication by Wen-Shiung Lour and Chung-Cheng Chang in Solid States Electronics, vol. 39, issue 9, pp. 1295-1298 (1986) ("Wen") in view of applicant's prior art disclosure in Figs. 2 and 3 ("APD").

In accordance with the present response, independent claim 1 has been amended to further patentably distinguish from the prior art of record by defining with more particularity that an interface level region of the surface of the semiconductor substrate does not exist between the semiconductor layers, which, as further discussed below, is

not disclosed or suggested by the prior art of record. New claims 15 and 16 have been added to provide a fuller scope of coverage. A new abstract which more clearly reflects the invention to which the amended and new claims are directed has been substituted for the previously submitted abstract.

Attached hereto is a marked-up version of the changes made to the abstract and independent claim 1 by the current amendment. The attached pages i-ii are captioned **"VERSION WITH MARKINGS TO SHOW CHANGES MADE"**.

Applicant respectfully requests reconsideration of his application in light of the following discussion.

#### **Brief Summary of the Invention**

The present invention is directed to a short-wavelength photodiode of enhanced sensitivity with low leak current.

As described in the specification (pgs. 1-3), the detection of light sensitivity in a short wavelength region by conventional photodiodes is inferior. Furthermore, the conventional photodiodes are associated with high leak current.

The present invention overcomes the drawbacks of the conventional art. Fig. 1 shows a photodiode according to the present invention embodied in amended independent claim 1.

The photodiode comprises an optical detection portion for detecting an optical signal and outputting a photoelectric conversion signal. The optical detection portion has a semiconductor substrate 1 of a first conductive type and semiconductor layers 2a, 2b of a second conductive type formed in spaced-apart relation in a surface of the semiconductor substrate. A depletion layer 3 is formed in the semiconductor substrate 1 by application of a reverse bias to the photodiode so as to surround the semiconductor layers 2a, 2b. An etched surface portion (denoted by X in the copy of Fig. 1 submitted herewith as Exhibit A) of the depletion layer 3 is disposed between the semiconductor layers 2a, 2b so that an interface level region of the surface of the semiconductor substrate 1 does not exist between the semiconductor layers 2a, 2b.

By the foregoing photodiode construction, the present invention provides a short-wavelength photodiode of enhanced sensitivity and with low leak current. By etching the surface portion of the depletion layer which is disposed between the semiconductor layers so that the interface level region of the surface of the semiconductor substrate does not exist between the semiconductor layers, leak current is controlled without greatly influencing the photo sensitivity of the photodiode.

The prior art of record does not disclose or suggest the subject matter recited in amended independent claim 1, dependent claims 2-7 and newly added claims 15-16.

#### **Traversal of Prior Art Rejection**

Claims 1-7 were rejected under 35 U.S.C. §103(a) as being unpatentable over Wen in view of APD. Applicant respectfully traverses this rejection and submits that the combined teachings of Wen and APD. do not disclose or suggest the subject matter recited in amended independent claim 1 and dependent claims 2-7.

Independent claim 1 is directed to a photodiode and requires an optical detection portion for detecting an optical signal and outputting a photoelectric conversion signal, the optical detection portion having a semiconductor substrate of a first conductive type, a plurality of semiconductor layers of a second conductive type formed in spaced-apart relation in a surface of the semiconductor substrate, and a depletion layer formed in the semiconductor substrate by application of a reverse bias to the photodiode so as to surround the semiconductor layers. Amended independent claim 1 further requires that the depletion layer has an etched surface portion disposed between the semiconductor layers so that an interface level region of the surface of the semiconductor

substrate does not exist between the semiconductor layers. No corresponding structural combination is disclosed or suggested by the prior art of record.

The primary reference to Wen discloses a PIN photodiode. With reference to Fig. 1 of Wen et al. which has been reproduced herewith as Exhibit B, the PIN photodiode has a P-Si substrate (corresponding to the semiconductor substrate of the claimed invention), an n-type ZnSe layer (corresponding to the semiconductor layers in the claimed invention) formed on the P-Si substrate, and two n+ layers spaced-apart from one another and disposed on the n-type ZnSe layer. The n+ layers are employed as ohmic contacts for the n-type ZnSe layer and an electrode formed on the n+ layers. The n+ layers have an etched surface portion for the purpose of forming an electrode pattern and removing a light obstacle. A depletion layer is formed in the n-type ZnSe layer above the P-Si substrate.

In the statement of rejection, the Examiner contends that the P-Si substrate and the n-type ZnSe layer in Wen correspond to the semiconductor substrate in independent claim 1 and that the n+ layers (i.e., ohmic contacts) correspond to the semiconductor layers in independent claim 1. The Examiner further contends that a boundary between the portion of the n+ layers that has been etched away and the n-type ZnSe layer corresponds to the etched surface portion recited in

independent claim 1. Applicant respectfully disagrees with the Examiner's contentions and with the Examiner's interpretation of the references in the rejection of the claims.

Wen does not disclose or describe a plurality of semiconductor layers formed in spaced-apart relation in a surface of the semiconductor substrate, and a depletion layer surrounding the semiconductor layers and having an etched surface portion disposed between the semiconductor layers so that an interface level region of the surface of the semiconductor substrate does not exist between the semiconductor layers, as required by amended independent claim 1. Stated otherwise, contrary to the Examiner's contention, the n-type ZnSe layer in Wen does not comprise a plurality of semiconductor layers formed in spaced-apart relation in a surface of the semiconductor substrate, as required by amended independent claim 1. Furthermore, the depletion layer in Wen does not have an etched surface portion disposed between the semiconductor layers so that an interface level region of the surface of the semiconductor substrate does not exist between the semiconductor layers, as required by amended independent claim 1. In this regard, as described above, the etched surface portion in Wen corresponds to the n+ layers, not the depletion layer. The depletion layer in Wen clearly does not

have an etched surface portion and, more specifically, an etched surface portion disposed between semiconductor layers formed in spaced-apart relation in a surface of a semiconductor substrate, and that an interface level region of the surface of the semiconductor substrate does not exist between the semiconductor layers, as required by amended independent claim 1.

Moreover, even if the structure of the PIN photodiode disclosed by Wen is interpreted in the manner proposed by the Examiner, applicant respectfully submits that the resulting structure does not meet the limitations required by amended independent claim 1. More specifically, amended independent claim 1 requires that the depletion layer has an etched surface portion disposed between the semiconductor layers so that an interface level region of the surface of the semiconductor substrate does not exist between the semiconductor layers. While Wen discloses that the n+ layers have an etched surface portion, there is no disclosure or suggestion that the exposed surface of the n-type ZnSe layer (corresponding to the surface of the semiconductor substrate of independent claim 1 in accordance with the Examiner's interpretation) has been etched away. Thus, even by the Examiner's interpretation, the resulting structure of Wen would at best correspond to the structure of the conventional

photodiode shown in Fig. 3, where the interface level region of the semiconductor substrate has not been removed.

The secondary reference to APD has been cited by the Examiner for its disclosure of a photodiode having a depletion layer 3 surrounding the semiconductor layers 2 (Fig. 3). However, APD does not disclose or suggest that the depletion layer 3 has an etched surface portion disposed between the semiconductor layers so that an interface level region of the surface of the semiconductor substrate does not exist between the semiconductor layers, as required by amended independent claim 1. In the photodiode of APD, an interface level region 4 of the semiconductor substrate 1 exists between the semiconductor layers 2. Since APD does not disclose or suggest these features, it does not cure the deficiencies of Wen. Accordingly, one of ordinary skill in the art would not have been led to modify the references to attain the claimed subject matter.

In order to support a claim rejection based upon obviousness under 35 U.S.C. §103, the Examiner must provide an evidentiary basis establishing the obviousness of each modification. The Examiner may do this by citing a reference which directly establishes this obviousness, or, the Examiner may otherwise set forth a line of reasoning consistent with and motivated by the cited art establishing that such



modifications would have been obvious. Mere speculation or conclusory allegations are simply inadequate to meet this burden. There must be some teaching, reason, suggestion, or motivation found in the prior art references to make a combination which renders an invention obvious within the meaning of 35 U.S.C §103. See, e.g., Symbol Technologies, Inc. v. Opticon, Inc., 935 F.2d 982, 989, 18 USPQ2d 1885 (Fed. Cir. 1991).

In order to set forth a prima facie case of obviousness, the Examiner must not only demonstrate that this teaching exists in the prior art, but that it would teach all limitations of the claim. This burden cannot be met by citing references that, even if combined, fail to teach explicitly recited limitations.

Stated otherwise, in rejecting a claim as obvious under 35 U.S.C. §103, the Examiner cannot simply rely on a combination of references that teach some limitations of the claim, and make mere conclusory allegations that the combination teaches others as well.

In the instant case, the Examiner has not met his burden of establishing a prima facie case of obviousness as discussed above.

As noted by the Court of Appeals for the Federal Circuit in the case of In re Fritch, 23 USPQ2d 1780, 1783 (Fed. Cir. 1992):

'Obviousness cannot be established by combining the teachings of the prior art to produce the claimed invention, absent some teaching or suggestion supporting the combination. Under section 103, teachings of references can be combined only if there is some suggestion or incentive to do so.' Although couched in terms of combining teachings found in the prior art, the same inquiry must be carried out in the context of a purported obvious 'modification' of the prior art. The mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification. Wilson and Hendrix fail to suggest any motivation for, or desirability of, the changes espoused by the Examiner and endorsed by the Board.

Here, the Examiner relied upon hindsight to arrive at the determination of obviousness. It is impermissible to use the claimed invention as an instruction manual or 'template' to piece together the teachings of the prior art so that the claimed invention is rendered obvious. This court has previously stated that '[o]ne cannot use hindsight reconstruction to pick and choose among isolated disclosures in the prior art to deprecate the claimed invention.'

As further noted by the Federal Circuit in In re Oeticker, 24 USPQ2d 1443, 1444 (Fed. Cir. 1992):

The prima facie case is a procedural tool of patent examination, allocating the burdens of going forward as between examiner and applicant. In re Spada, 911 F.2d 705, 707 n.3, 15 USPQ2d 1655, 1657 n.3 (Fed. Cir. 1990). The term 'prima facie case' refers only to the initial examination step. In re Piasecki, 745 F.2d 1468, 1472, 223 USPQ 785, 788 (Fed.

Cir. 1984); In re Rinehart, 531 F.2d 1048, 1052, 189 USPQ 143, 147 (CCPA 1976). As discussed in In re Piasecki, the examiner bears the initial burden, on review of the prior art or on any other ground, of presenting a prima facie case of unpatentability. If that burden is met, the burden of coming forward with evidence or argument shifts to the applicant.

\* \* \*

If examination at the initial stage does not produce a prima facie case of unpatentability, then without more the applicant is entitled to grant of the patent. See In re Grabiak, 769, F.2d 729, 733, 226 USPQ 870, 873 (Fed. Cir. 1985); In re Rinehart, supra.

In reviewing the examiner's decision on appeal, the Board must necessarily weigh all of the evidence and argument. An observation by the Board that the examiner made a prima facie case is not improper, as long as the ultimate determination of patentability is made on the entire record. In re Piasecki, 745 F.2d at 1472, 223 USPQ at 788; In re Rinehart, 531 F.2d at 1052, 189 USPQ at 147.

The Federal Circuit has therefore made it clear that the prior art must show an incentive to modify its teachings in order to render a claim obvious. Without such an incentive, a prima facie case of obviousness cannot be made.

Claims 2-7 depend on and contain all of the limitations of amended independent claim 1 and, therefore, distinguish from the references at least in the same manner as claim 1.

In view of the foregoing, applicant respectfully requests that the rejection of claims 1-7 under 35 U.S.C. §103(a) as being unpatentable over Wen in view of APD be withdrawn.

Applicant respectfully submits that the prior art of record also does not disclose or suggest the subject matter recited in newly added claims 15-16.

New independent claim 15 is directed to a photodiode and requires an optical detection portion for detecting an optical signal and outputting a photoelectric conversion signal. Claim 15 requires that the optical detection portion has a semiconductor substrate of a first conductive type and a plurality of semiconductor layers of a second conductive type disposed in spaced-apart relation in a surface of the semiconductor substrate so that an interface level region of the surface of the semiconductor substrate does not exist between the semiconductor layers. No corresponding structural combination is disclosed or suggested by the prior art of record as set forth above for amended independent claim 1.

Claim 16 depends on and contains all of the limitations of amended independent claim 1 and, therefore, distinguishes from the references at least in the same manner as claim 1.

In view of the foregoing amendments and discussion,  
the application is believed to be in allowable form.  
Accordingly, favorable reconsideration and allowance of the  
claims are most respectfully requested.

Respectfully submitted,

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20231, on the date indicated below.

  
Bruce L. Adams

Attorney for Applicant

Signature

NOVEMBER 14, 2002

Date

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE ABSTRACT:

The abstract has been amended as follows:

A photodiode comprises an optical detection portion for detecting an optical signal and outputting a photoelectric conversion signal. The optical detection portion has a semiconductor substrate of a first conductive type and semiconductor layers of a second conductive type formed in spaced-apart relation in a surface of the semiconductor substrate. A depletion layer is formed in the semiconductor substrate by application of a reverse bias to the photodiode so as to surround the semiconductor layers. An etched surface portion of the depletion layer is disposed between the semiconductor layers so that an interface level region of the surface of the semiconductor substrate does not exist between the semiconductor layers.

IN THE CLAIMS:

1. (Thrice Amended) A photodiode comprising: an optical detection portion for detecting an optical signal and outputting a photoelectric conversion signal, the optical detection portion having a semiconductor substrate of a first conductive type, a plurality of semiconductor layers of a

second conductive type formed in spaced-apart relation in a surface of the semiconductor substrate, and a depletion layer formed in the semiconductor substrate by application of a reverse bias to the photodiode so as to surround the semiconductor layers, the depletion layer having an etched surface portion disposed between the semiconductor layers so that an interface level region of the surface of the semiconductor substrate does not exist between the semiconductor layers.

EXHIBIT A

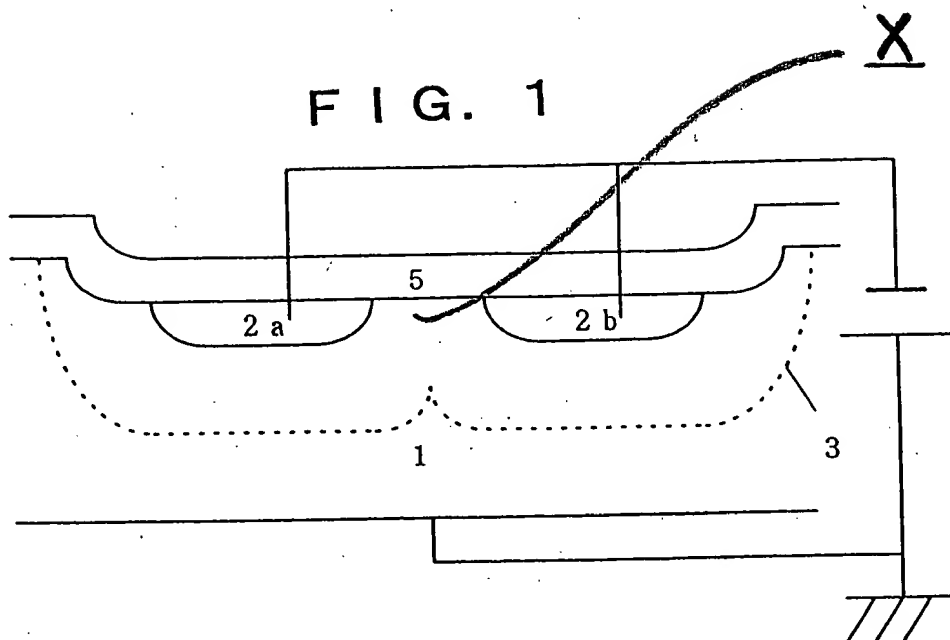


EXHIBIT B

